

GE

TOWNE

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Phillips '96.

Weston Engine.

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An Investigation
Of
The Efficiencies and Losses
Of
A Weston Engine
And
A Thomson-Houston Dynamo.

Harry Laird Phillips.
Sept. '98

TOWNE

378.748

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4 June '48. Sec. of Univ. P. H. L.



The object of this thesis was the determination of the mechanical efficiency of the engine with various loads, the separation of the losses occurring in the dynamo and the finding of its efficiency under varied voltage.

The engine, built by the Weston Co., was a horizontal, D-slide, non-condensing one, of the fly-wheel governor type.

The dimensions were

Diam of cylinder --- 6 in.

" " piston-rod --- $1\frac{1}{8}$ "

" " fly-wheels $36\frac{1}{4}$ "

Stroke --- 8 "

The dynamo, a J.H. arc machine, was rated as of

1½ kilowatts, when driven at 1250 r.p.m. It regulated for a constant current of approximately 6.7 amperes.

Two Tabor indicators - one for each end of the cylinder - were used.

The engine was first run with no load, and at different revolutions per minute. Cards being taken, the indicated horse power was gotten and hence the work necessary to overcome friction.

Next a Prony brake was put on and cards being again taken the mechanical efficiency for the different loads was gotten from the brake and indicated horse power.

The engine and dynamo being belted together, a current was sent

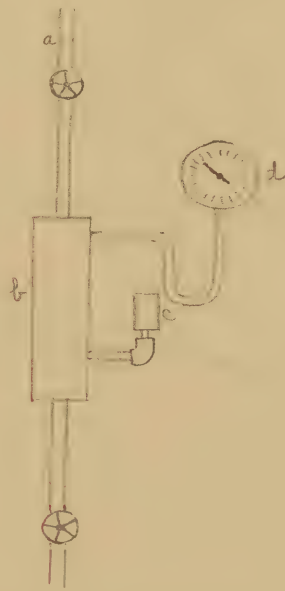
from an outside source in such a direction as to demagnetise the fields and then the horse power indicated showed the work used up in friction of the bearings of engine and dynamo, of the brushes and the loss in the belt.

Next a current of normal strength was maintained in the fields, from outside, and the armature being disconnected, on running the engine the losses above mentioned and also those due to hysteresis and eddy currents were indicated on the cards.

Finally the dynamo was connected normally, a variable external resistance introduced and readings of the volts and amperes taken simultaneously with an-

indicator cards.

Three indicator springs were used - nominally of 24, 40, 20, and 16 lbs per inch, strength. They were calibrated by means of an arrangement in the hydraulic laboratory.



The line of piping containing live steam. a - is connected with a cylinder. b - on two pipes projecting from which are screwed

an indicator c and gauge d. It
card is put in place on the
drum, and a spring being put
under steam is gradually turned
on. By means of a string at-
tached to the drum, it is re-
volved as each additional pressure
of ten pounds is reached and a
pencil traces a corresponding line.
When the maximum pressure has
been reached, by gradually closing
the valve a similar set of lines for
the descent of the gauge needle may
be gotten.

The gauge is
then corrected by means of a
Brosby gauge tester.

The object
here, is to place various weights on
a platform forming the top of a
plunger working in oil and pro-
ducing pressures per sq. in. of 5, 10, etc.

As each actual pressure is gotten the reading of the gauge is noted and then a curve plotted between noted and exact pressures as coordinates for ascending readings, and a similar one for descending readings. From these curves, the true pressure for each gauge reading in connection with the indicator test, may be found.

Gauge calibration.

asc.	True	Desc.		asc.	True	Desc.
12	10	13		57	55	58
17	15	18		62	60	63
22	20	23		67	65	68
27	25	28		72	70	73
32	30	33		76½	75	77½
37	35	38		81½	80	83
42	40	43½		86½	85	88
47	45	48		91½	90	92
52	50	53		96½	95	97
				101	100	101

(1) <u>Asc</u>			
gauge	lbs.	in.	lpsr
0	1	0	0
20	18	.35	51.4
30	28	.54	51.8
40	38	.74	51.3
50	48	.92	51.1
60	58	1.12	51.7
70	68	1.31	51.9
80	78.5	1.51	51.9
90	88.6	1.69	51.4
Avg 51.8			

Spring calibration

gauge	lbs.	in.	lpsr
20	18	.34	52.9*
30	28	.55	50.9
40	38	.72	52.7
50	48	.92	52.1
60	58	1.11	52.2
70	68	1.31	51.9
80	78.5	1.51	51.9
90	88.6	1.71	51.8
Avg 51.8			

(3) <u>Asc.</u>			
gauge	lbs.	in.	lpsr
20	18	.32	56.2*
30	28	.52	53.8*
40	38	.70	54.3*
50	48	.90	53.3*
60	58	1.10	52.7
70	68	1.31	51.9
80	78.5	1.50	52.3
90	88.6	1.70	52.1
Avg 52.2			

<u>Desc</u>			
gauge	lbs.	in.	lpsr
90	87	1.66	51.4
80	77.5	1.47	52.7
70	68	1.29	52.7
60	58	1.11	52.2
50	48	.90	53.3
40	38	.72	52.7
30	28	.53	52.8*
20	18	.34	52.9*
Avg 52.1			

<u>Desc</u>			
gauge	lbs.	in.	lpsr
90	87	1.82	47.9
80	77.5	1.62	47.7
70	68	1.43	47.6
60	58	1.26	46.0*
50	48	1.06	45.3
40	38	.85	44.8
30	28	.66	42.4
20	18	.45	40.0

<u>Desc</u>			
gauge	lbs.	in.	lpsr
90	87	1.68	51.7
80	77.5	1.49	52.0
70	68	1.30	52.3
60	58	1.10	52.7
50	48	.90	53.3*
40	38	.70	54.2*
30	28	.52	53.8*
20	18	.33	54.5*
Avg 52.2			

(1) <u>Asc</u>			
gauge	lbs.	in.	lpsr
80	87.6	2.14	38.6
80	185	4.00	34.3
70	68	1.76	38.6
60	58	1.51	38.4
50	48	1.29	38.7
40	38	1.03	38.3
30	28	.77	36.4*
20	18	.51	35.2*
Avg 38.5			

(2) <u>Asc</u>			
gauge	lbs.	in.	lpsr
90	88.6	2.33	38
80	78.5	2.05	38.3
70	68	1.77	38.5
60	58	1.55	37.4*
50	48	1.29	37.2*
40	38	1.03	36.9*
30	28	.77	36.4*
20	18	.51	35.2*
Avg 38.3			

(3) <u>Asc</u>			
gauge	lbs.	in.	lpsr
20	18	.51	35.2*
30	28	.75	37.3*
40	38	1.03	36.9*
50	48	1.27	37.8
60	58	1.51	38.4
70	68	1.78	38.3
80	78.5	2.05	38.3
90	88.6	2.27	39.0
Avg 38.5			

<u>Desc</u>			
gauge	lbs.	in.	lpsr
90	87	2.26	38.3
80	77.5	1.94	39.1
70	68	1.74	39.1
60	58	1.56	38.6
50	48	1.33	39.0
40	38	.99	38.4
30	28	.72	38.9*
20	18	.46	39.1*
Avg 38.5			

<u>Desc</u>			
gauge	lbs.	in.	lpsr
90	87	2.24	38.9
80	77.5	2.01	38.6
70	68	1.76	38.6
60	58	1.51	38.4
50	48	1.26	38.1
40	38	.99	38.4
30	28	.73	38.4
20	18	.48	37.5
Avg 38.5			

<u>Desc</u>			
gauge	lbs.	in.	lpsr
90	87	2.24	38.9
80	77.5	1.98	39.1
70	68	1.74	39.1
60	58	1.51	38.5
50	48	1.23	39.0
40	38	.96	39.6
30	28	.72	38.9
20	18	.46	39.1
Avg 39.1			

(1) <u>Asc.</u>				(2) <u>Asc.</u>				(3) <u>Asc.</u>			
gauge	lbs.	in.	lbs per in.	gauge	lbs.	in.	lbs per in.	gauge	lbs.	in.	lbs per in.
30	28.	1.43	19.6	30	28	1.46	19.2	30	28	1.46	19.2
25	15.	1.18	19.5	25	15	1.21	19.7	25	23	1.20	19.2
20	18.	.91	19.8	20	18	.95	19.0	20	18	.95	19.0
15	13.	.65	20.0	15	13	.65	20.0	15	13	.68	19.1
10	8.5	.40	21.2*	10				10	8.5	.42	20.3
Ave 19.7				Ave 19.4				Ave 19.4			

20 <u>Desc.</u>				20 <u>Desc.</u>				20 <u>Desc.</u>			
gauge	lbs.	in.	lbs per in.	gauge	lbs.	in.	lbs per in.	gauge	lbs.	in.	lbs per in.
30	27	1.42	19.	30	27	1.40	19.3	30	27	1.39	19.4
25	22	1.14	19.3	25	22	1.15	19.1	25	22	1.14	19.3
20	17	.90	19	20	17	.90	19.	20	17	.89	19.1
15	12	.64	18.8	15	12	.65	18.5	15	12	.64	18.8
10	8	.385	20.8	10	8	.40	20.0	10	8	.40	20.0
Ave 19.4				Ave 18.8				Ave 19.3			

11 <u>Asc.</u>				15 <u>Asc.</u>				15 <u>Asc.</u>			
gauge	lbs.	in.	lbs per in.	gauge	lbs.	in.	lbs per in.	gauge	lbs.	in.	lbs per in.
20	17	1.10	15.5	20	18	1.20	15.0	20	18	1.20	15.0
15	12	.79	15.2	15	13	.84	15.2	15	13	.87	15.0
10	8	.47	17.0*	10	8.5	.50	17.0*	10	8.5	.55	15.4
Ave 15.4				Ave 15.3				Ave 15.2			

16 <u>Desc.</u>				16 <u>Desc.</u>				16 <u>Desc.</u>			
gauge	lbs.	in.	lbs per in.	gauge	lbs.	in.	lbs per in.	gauge	lbs.	in.	lbs per in.
20	17	1.20	15.0	20	17	1.13	15.1	20	17	1.20	14.2
15	12	.79	15.2	15	12	.79	15.2	15	12	.79	15.2
10	8	.49	17.0*	10	8	.46	17.0*	10	8	.49	16.3
Ave 15.2				Ave 15.2				Ave 15.2			

* Omitted

Result	50	52.1 lbs per in.
	40	38.7 " " "
	20	19.4 " " "
	16	15.3 " " "

Spring 20, 16 were used for revolutions below 360.

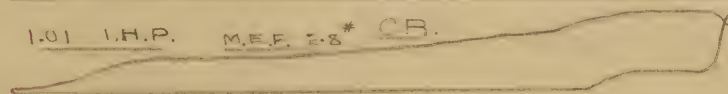
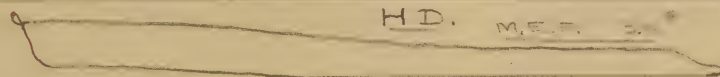
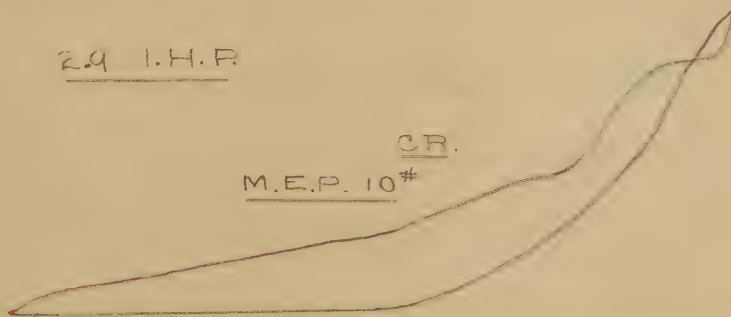
Sample cards



7b



3c



5c

The resistance of the fields was found by means of a volt meter and an ammeter.

With	6.9 amperes,	20.7 volts	P.M. * 3
"	3.43	10.3	Alt. 26

were gotten. The resistance was therefore 3W.

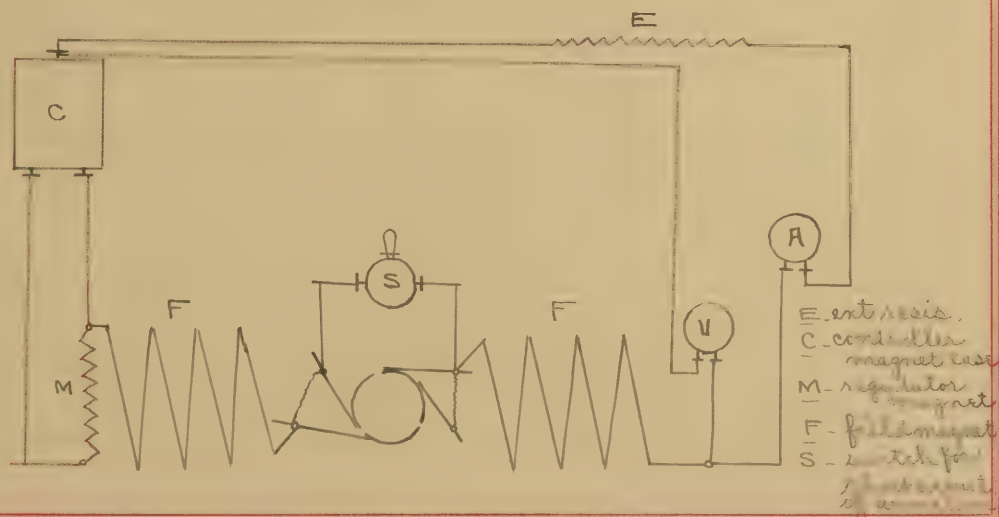
With the brushes properly adjusted, the resistance of the armature is always that of one of its three coils (when in the extreme positions of the regulator arm) so that their average value was taken.

The dynamo having been running for several hours, the resistance was taken (by means of Wheatstone bridge #40) as soon as it was stopped.

The three coils were found to be of $\begin{matrix} 4.65 \\ 4.55 \\ 4.50 \end{matrix}$ W (an. 4.57) resistance. The resistance of the connecting wires

was now, leaving us with the armature resistance.

The final set of cards was taken with a resistance frame joined in as the external resistance. In order to read higher voltages than the Weston voltmeters in the laboratory were graduated to, a resistance equal to that of the voltmeter (as per pt. 1°) was joined with it, using boxes #46 and #47. Each division ordinarily for one volt, then indicated two volts.



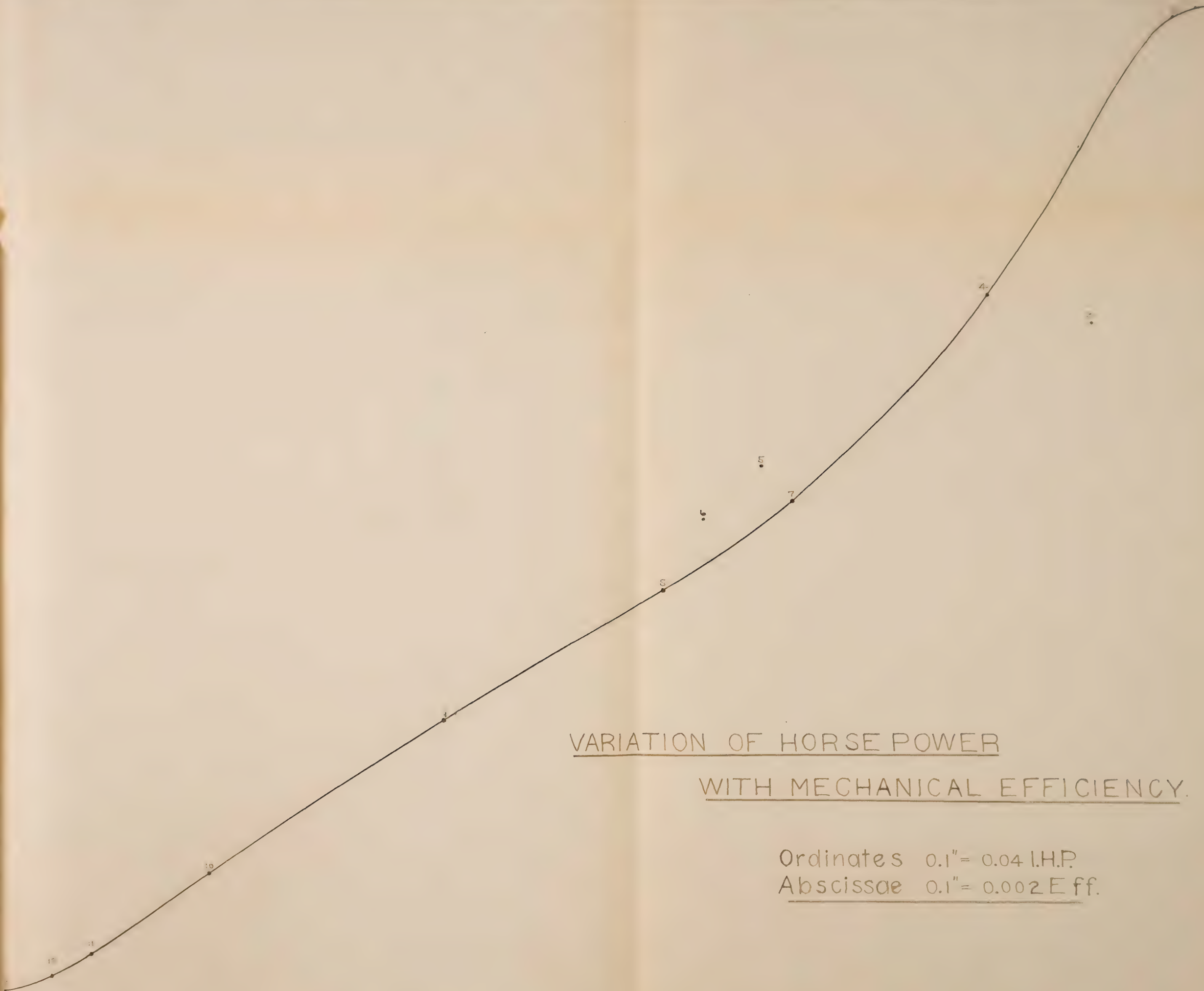
Brake horse-power cards.

Card	Sex	Age	Length	Mat.	Sex.	Brake Load	B.H.P.	Area	Wt. H.P.
1b	H	1.98	3.84	20	364	63*	6.68	8.60	.776
	C	1.51	3.80	22.1					
2b	H	1.95	3.84	19.7	366	62	6.60	8.57	.771
	C	1.62	3.83	22.1					
3b	H	1.56	3.84	15.7	364	51	5.42	7.20	.754
	C	1.43	3.82	19.5					
4b	H	1.71	3.84	17.3	362	52	5.50	7.51	.731
	C	1.46	3.86	19.7					
5b	H	1.43	3.88	14.4	362	42	4.46	6.55	.680
	C	1.31	3.84	17.8					
6b	H	1.33	3.84	13.4	364	40	4.25	6.37	.667
	C	1.32	3.86	17.8					
7b	H	1.02	3.84	13.4	360	42	4.41	6.41	.687
	C	1.79	3.86	17.9					
8b	H	0.903	3.87	12.2	366	37	3.95	6.00	.658
	C	1.71	3.87	17.1					
9b	H	0.70	3.86	11.1	365	31	3.30	5.42	.609
	C	1.54	3.87	15.4					
10b	H	0.658	3.85	8.7	365	25	2.66	4.74	.561
	C	1.45	3.86	14.5					
11b	H	0.55	3.84	7.5	364	22	2.34	4.39	.532
	C	1.38	3.82	14.0					
12b	H	0.432	3.81	5.95	367	21	2.25	4.30	.522
	C	1.42	3.87	14.4					
13b	H	0.425	3.80	5.82	365	20	2.13	4.18	.509
	C	1.47	3.89	14.6					

* The figures in this column include the weight of the brake - 2 lbs.

In the column of areas, the lesser of each pair was made by the stronger

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VARIATION OF HORSE POWER

WITH MECHANICAL EFFICIENCY.

Ordinates $0.1'' = 0.04 \text{ I.H.P.}$

Abcissae $0.1'' = 0.002 \text{ Eff.}$

of the two springs - 40 and 50.

In plotting the efficiency curves .509 eff. and 4.04 i.h.p. correspond to the zero point.

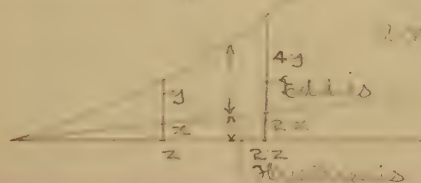
In plotting the curves of the several losses, the zero point corresponds with 0.3 i.h.p. and 400 r.p.m.

The abscissae being dynamo revolutions, in order to have on the same plot, the results for engine friction, the revolutions of the engine were altered to corresponding revolutions of the dynamo as had from later cards.

- Eddy current losses vary as the square of the speed, and hysteresis losses, as the speed directly.

Hence, if z be any speed (00 rev. on plot)

and $2z$ twice that speed



$$\begin{aligned} x + y &= z \\ 2x + 4y &= b \\ \text{or } x &= \frac{4a - b}{2} \end{aligned}$$

Cards for engine friction.

Card	Size	Length	M.P.	Rev.	Time
1w	H 0.14	3.85	2.58	370	2.36
	C 0.865	3.80	8.82		
2w	H 0.075	3.82	1.02	368	1.01
	C 0.62	3.80	6.31		
3a	H 0.07	3.86	0.45	368	2.04
	C 0.88	3.82	8.42		
4w	H 0.30	3.85	4.06	371	2.31
	C 0.79	3.82	8.02		
5a	H 0.235	3.83	3.20	364	2.50
	C 0.875	3.82	8.88		
6a	H 0.11	3.85	1.44	368	2.21
	C 0.41	3.83	4.21		
7w	H 0.61	3.79	2.78	364	2.31
	C 4.27	3.77	8.38		
8a	H 0.14	3.76	1.44	370	1.92
	C 0.57	3.79	7.84		
9a	H 0.175	3.78	1.30	370	2.13
	C 0.615	3.80	8.44		
10a	H 0.155	3.72	1.61	367	2.06
	C 0.61	3.79	8.38		
11w	H 0.76	3.76	2.48	367	2.21
	C 0.885	3.80	8.02		
12w	H 0.30	3.76	3.09	368	2.17
	C 0.535	3.78	7.38		
13a	H 0.435	3.68	1.81	180	0.390
	C 0.396	3.74	2.05		
14a	H 0.445	3.70	1.84	168	0.339
	C 0.34	3.74	1.76		
15a	H 0.385	3.74	2.40	162	0.388
	C 0.36	3.73	1.87		
16a	H 0.705	3.70	2.42	160	0.481
	C 0.455	3.72	2.37		
17w	H 0.565	3.70	2.34	156	0.398
	C 0.40	3.70	2.10		
18a	H 0.735	3.70	3.00	249	0.468
	C 0.43	3.72	2.35		
19w	H 0.86	3.73	3.52	251	0.740
	C 0.345	3.76	1.78		

Card	Area	Length	M.B.P.	Riv.	W.P.
11	0.87	3.77	3.54		
20a	0.50	3.75	2.59	251	0.665
	H	0.595	3.74	3.09	
21a	C	0.855	3.71	3.53	235
	H	0.92	3.73	3.78	
22a	C	0.505	3.75	2.61	248
	H	0.80	3.73	3.28	
23a	C	0.48	3.76	2.49	244
	H	0.79	3.71	3.265	
24a	C	0.55	3.75	2.845	245
	H	0.455	3.70	1.89	
25a	C	0.39	3.74	2.02	220
	H	0.48	3.65	2.02	
26a	C	0.32	3.73	1.66	210
	H	0.48	3.69	1.99	
27a	C	0.325	3.72	1.70	205
	H	0.49	3.69	2.03	
28a	C	0.42	3.70	2.21	200
	H	0.56	3.68	2.33	
29a	C	0.45	3.74	2.34	198
	H	0.62	3.68	2.58	
30a	C	0.46	3.70	2.42	191
	H	0.54	3.75	2.20	
31a	C	0.425	3.74	2.21	278
	H	0.565	3.73	2.32	
32a	C	0.535	3.75	2.77	278
	H	0.55	3.71	2.27	
33a	C	0.45	3.77	2.32	290
	H	0.505	3.72	2.08	
34a	C	0.51	3.75	2.64	282
	H	0.895	3.77	3.64	
35a	C	0.55	3.80	2.81	320
	H	0.705	3.75	2.88	
36a	C	0.52	3.77	2.68	330
	H	0.74	3.75	3.02	
37a	C	0.67	3.75	3.47	320
	H	0.645	3.73	2.65	
38a	C	0.48	3.76	2.48	300

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Cards giving the combined losses in friction
of engine and dynamo and belt transmission

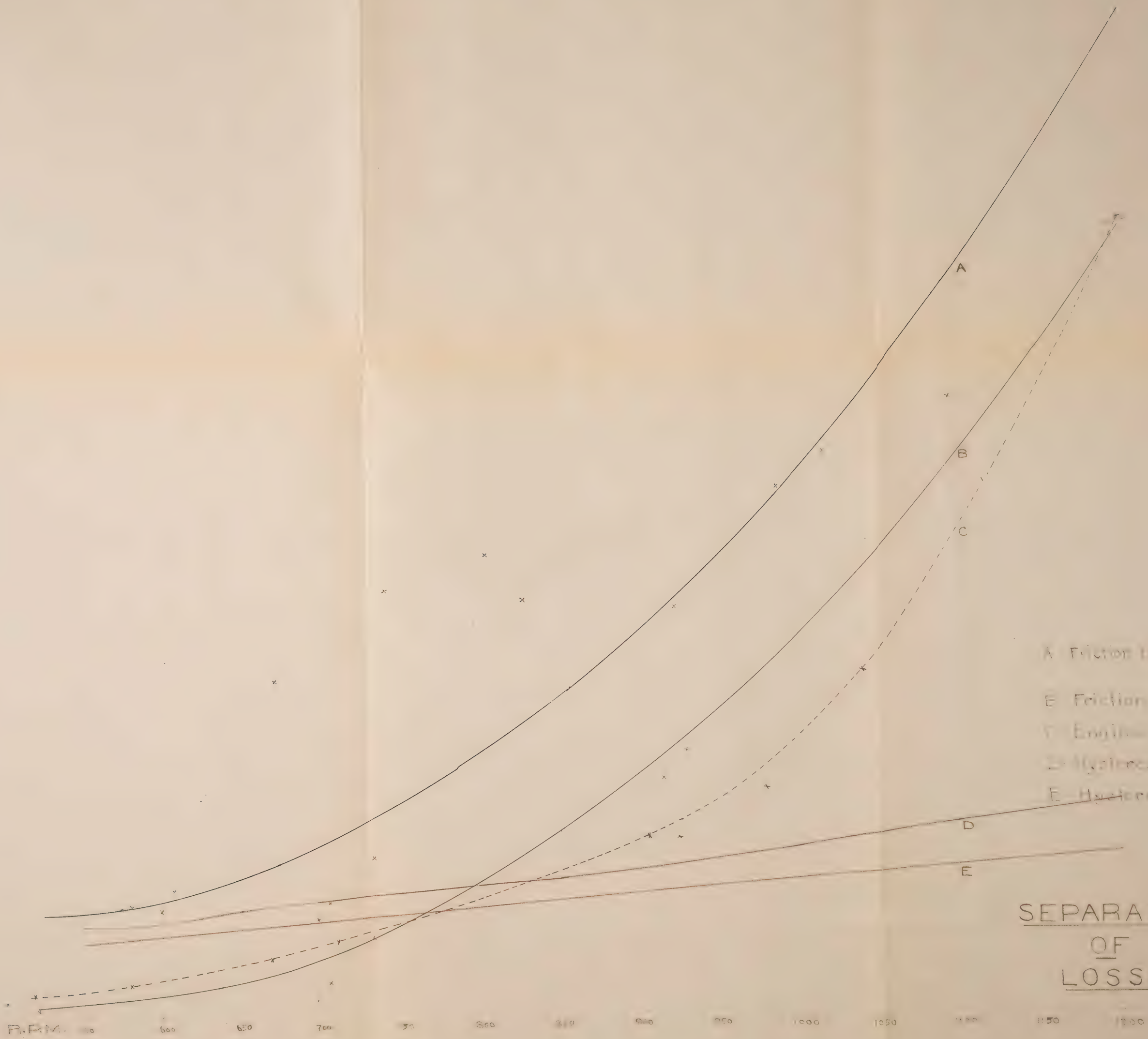
Card		Area	Length	M.F.P.	Engine Rev.	Dynamo Rev.	W.H.P.
1c	H	0.135	3.72	1.89	370	1202	2.045
	C	0.80	3.88	7.98			
2c	H	0.33	3.68	4.68	371	1205	2.805
	C	0.86	3.77	8.84			
3c	H	0.28	3.68	3.96	367	1200	2.88
	C	0.98	3.78	10.00			
4c	H	0.185	3.76	2.57	371	1205	2.20
	C	0.78	3.78	8.00			
5c	H	0.66	3.74	3.43	290	930	1.01
	C	0.69	3.75	2.82			
6c	H	0.57	3.74	2.96	280	915	0.919
	C	0.71	3.76	2.89			
7c	H	0.44	3.74	2.28	280	915	0.863
	C	0.78	3.72	3.205			
8c	H	0.60	3.73	3.12	290	930	0.902
	C	0.595	3.75	2.43			
9c	H	0.30	3.70	1.57	155	498	0.300
	C	0.455	3.68	1.89			
10c	H	0.305	3.62	1.63	156	502	0.372
	C	0.63	3.68	2.62			
11c	H	0.35	3.68	1.85	165	522	0.320
	C	0.39	3.70	1.61			
12c	H	0.455	3.70	2.39	220	710	0.604
	C	0.61	3.72	2.51			
13c	H	0.485	3.70	2.545	225	732	0.694
	C	0.715	3.72	2.94			
14c	H	0.385	3.71	2.02	220	700	0.557
	C	0.61	3.72	2.50			
15c	H	0.425	3.70	2.23	218	698	0.543
	C	0.535	3.70	2.22			

Ends giving combined losses due to friction, bell

hysteresis and eddy currents.

Card		Area	Length	M.E.P.	Engine R.P.M.	Dyna R.P.M.	Eff. %
1d	H	0.135	3.78	1.86	370	1204	2.325
	C	0.905	3.76	9.34			
		0.25	3.77	3.46	370	1200	2.32
2d		0.75	3.76	7.72			
		0.10	3.76	1.39	365	1190	2.175
3d		0.90	3.77	9.25			
		0.07	3.74	0.98	365	1192	2.185
4d		0.945	3.77	9.71			
		0.08	3.76	1.11	369	1204	2.17
5d		0.91	3.76	9.38			
		0.16	3.77	2.22	370	1206	2.425
6d		0.92	3.76	9.49			
		0.85	3.75	2.40	177	580	0.578
7d		0.94	3.75	3.35			
		0.655	3.73	2.68	177	574	0.577
8d		0.60	3.72	3.13			
		0.665	3.74	2.72	176	572	0.570
9d		0.58	3.72	3.05			
		0.61	3.73	2.50	185	597	0.519
10d		0.48	3.72	2.50			
		0.66	3.74	2.71	185	599	0.565
11d		0.525	3.72	2.74			
		0.715	3.73	2.93	185	602	0.635
12d		0.61	3.71	3.19			
		0.67	3.75	2.74	190	612	0.592
13d		0.535	3.71	2.80			
		0.66	3.75	2.70	190	615	0.641
14d		0.635	3.72	3.31			
		1.19	3.80	4.78	345	1120	1.83
15d		0.91	3.77	4.69			
		1.23	3.79	4.97	330	1072	1.84
16d		0.96	3.76	4.93			
		1.10	3.78	4.44	315	1030	1.70
17d		1.01	3.76	5.19			
		1.30	3.76	5.30	310	1002	1.72
18d		0.89	3.75	4.58			

Lead	Area	Length	M.E.D.	Wt.	Vol.	Unit
19d	H 1.16 C 0.92	3.76 3.75	4.72 4.76	304	488	1.52
20d	H 1.03 C 0.80	3.78 3.76	4.18 4.13	300	488	1.41
21d	H 0.88 C 0.66	3.78 3.75	3.57 3.42	294	486	1.15
22d	H 0.80 C 0.75	3.77 3.75	3.25 3.88	284	450	1.35
23d	H 1.00 C 0.78	3.78 3.75	4.06 4.04	286	926	1.30
24d	H 0.725 C 0.60	3.77 3.74	2.95 3.11	280	912	0.911
25d	H 0.98 C 0.75	3.76 3.75	3.97 3.86	278	903	1.11
26d	H 0.97 C 0.73	3.77 3.75	3.93 3.75	276	898	1.25
27d	H 1.015 C 0.765	3.77 3.74	4.13 3.97	271	880	1.25
28d	H 0.945 C 0.815	3.76 3.75	3.85 4.22	270	876	1.21
29d	H 0.86 C 0.715	3.77 3.76	3.49 3.69	268	870	1.08
30d	H 1.375 C 0.86	3.76 3.73	4.47 5.61	262	860	1.48
31d	H 1.215 C 0.87	3.75 3.73	4.97 4.53	254	830	1.56
32d	H 1.37 C 0.86	3.76 3.75	4.52 4.66	254	824	1.31
33d	H 1.41 C 1.135	3.75 3.74	5.76 5.89	250	812	1.65
34d	H 1.45 C 1.07	3.75 3.74	5.42 5.54	250	810	1.61
35d	H 1.22 C 1.04	3.75 3.75	4.98 5.38	250	804	1.46
36d	H 1.365 C 0.97	3.75 3.74	5.59 5.04	230	740	1.57
37d	H 1.24 C 0.91	3.75 3.74	5.06 4.72	208	670	1.14
38d	H 1.36 C 0.82	3.75 3.74	5.53 4.26	206	668	1.13



A Friction losses, hysteresis, and eddies
 B Friction Losses
 C Engine friction
 D Hysteresis (Eddies) (A-B)
 E Hysteresis.

SEPARATION OF LOSSES

Birds taken with the dynamo
doing external work.

Line	Sex	Length	Mass	Wing	Alar	Ext.	V	A	Ext.	W	W	W	W
	H	0.673	3.76	6.93	367	1187	4.12	134	6.6	1.716	2434	2.81	6.12.767.718
12	C	1.27	3.90	17.0	367	1187	4.66	197	6.4	1.686	244.9	2.57	6.57.712.700
	H	0.60	3.77	6.18	367	1187	4.66	197	6.4	1.686	244.9	2.57	6.57.712.700
20	C	1.23	3.88	16.4	367	1187	4.70	196.5	6.5	1.71	245.1	2.61	6.56.712.700
	H	0.56	3.76	5.77	367	1187	4.70	196.5	6.5	1.71	245.1	2.61	6.56.712.700
22	C	1.27	3.90	17.0	367	1187	4.70	196.5	6.5	1.71	245.1	2.61	6.56.712.700
	H	0.62	3.77	6.37	367	1187	4.63	175	6.8	1.596	2259	2.55	6.27.810.778
32	C	1.17	3.78	16.1	367	1187	4.63	175	6.8	1.596	2259	2.55	6.27.810.778
	H	0.575	3.76	5.93	362	1173	4.61	175.5	6.75	1.596	226.2	2.53.6	5.1.811.778
32	C	1.215	3.78	16.8	362	1173	4.61	175.5	6.75	1.596	226.2	2.53.6	5.1.811.778
	H	0.505	3.76	5.20	362	1181	4.27	177	6.77	1.606	227.7	2.22	7.26.936.777
6	C	1.146	3.78	15.8	362	1181	4.27	177	6.77	1.606	227.7	2.22	7.26.936.777
	H	0.505	3.76	5.20	367	1187	4.63	154.5	6.8	1.41	2054	2.55	5.53.772.778
11	C	1.245	3.76	17.25	367	1187	4.63	154.5	6.8	1.41	2054	2.55	5.53.772.778
	H	0.52	3.77	5.34	367	1187	4.27	154	6.8	1.406	2049	2.22	6.35.845.752
8	C	1.11	3.76	15.4	367	1187	4.27	154	6.8	1.406	2049	2.22	6.35.845.752
	H	0.56	3.76	5.77	365	1183	4.50	154	6.8	1.406	2049	2.43	5.580.777.751
11	C	1.18	3.77	16.3	365	1183	4.50	154	6.8	1.406	2049	2.43	5.580.777.751
	H	0.555	3.76	5.66	367	1187	4.45	136	6.8	1.24	1869	2.38	5.22.718.728
11	C	1.155	3.78	15.9	367	1187	4.45	136	6.8	1.24	1869	2.38	5.22.718.728
	H	0.535	3.76	5.51	366	1186	4.31	136	6.8	1.24	1869	2.26	5.51.767.728
116	C	1.12	3.77	15.5	366	1186	4.31	136	6.8	1.24	1869	2.26	5.51.767.728
	H	0.475	3.78	4.88	367	1187	4.12	1374	6.8	1.25	188.3	2.07	6.06.828.731
126	C	1.12	3.78	15.45	367	1187	4.12	1374	6.8	1.25	188.3	2.07	6.06.828.731
	H	0.56	3.76	5.77	367	1187	4.27	115	6.8	1.05	1659	2.72	4.74.684.644
136	C	1.08	3.77	14.9	367	1187	4.27	115	6.8	1.05	1659	2.72	4.74.684.644
	H	0.495	3.78	5.08	367	1187	3.89	115.5	6.8	1.055	166.4	1.88	5.11.510.697
146	C	1.005	3.79	13.8	367	1187	3.89	115.5	6.8	1.055	166.4	1.88	5.11.510.697
	H	0.515	3.77	5.3	367	1187	4.23	115.6	6.8	1.055	166.5	2.18	4.87.702.695
156	C	1.10	3.78	15.2	367	1187	4.23	115.6	6.8	1.055	166.5	2.18	4.87.702.695
	H	0.44	3.76	4.53	367	1187	3.86	94	6.9	0.869	1457	1.8	4.71.763.644
166	C	1.02	3.76	14.2	367	1187	3.86	94	6.9	0.869	1457	1.8	4.71.763.644
	H	0.43	3.75	4.44	367	1187	4.10	93	6.8	0.848	145.1	2.11	4.12.641.644
176	C	1.1	3.78	15.45	367	1187	4.10	93	6.8	0.848	145.1	2.11	4.12.641.644
	H	0.38	3.77	3.91	367	1187	4.08	92	6.8	0.840	142.9	2.0	4.12.641.644
186	C	1.145	3.77	15.85	367	1187	4.08	92	6.8	0.840	142.9	2.0	4.12.641.644

f electrical " i.e. $\frac{q}{r}$

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In these results, the losses due to transmission by belt have been neglected owing to a lack of time and of apparatus for their examination. The investigation would be made more complete by removing the dynamo, setting up a jack-shaft in its place (with a pulley of the same size) attaching a dynamometer as Emerson power scale (e.g. and then from a Brown base and the dynamometer, observing the power delivered and received by the belt.

Probably the use of a dynamometer on the shaft of the dynamo, would have been a more accurate means of determining the power delivered to it, than the use of indicator cards entirely. This is especially true if the experiment were again attempted by one person. Otherwise there might well be

three men, one to take cards, another, revolutions of engine and the third, revolutions of dynamo, simultaneously. This is the only way to obtain much accuracy if indicator cards are used throughout. This is so, because if the attempt be made to reduce the speed by partially closing the throttle valve, the engine will not run evenly in all cases, and if cards are taken and then the revolutions, the latter are apt to be different from what they were, at the moment of taking ^{the} cards.

The method of determining the losses (see Jackson p. 254) by running the machine as a motor, is probably a very good one involving however the use of a similar machine.



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